CLAIMS

We claim:

1. An inerting system, comprising:

an air separation module configured to receive an air flow from a pressurized air source, said air separation module generating a flow of nitrogen-enriched air from said air flow;

a turbine communicating with said flow of nitrogen-enriched air and powered thereby; and

a compressor disposed in said air flow between the air separation module and said source and said compressor being rotated by said turbine to increase the pressure of said air flow to the air separation module.

2. The inerting system of claim 1, wherein the air separation module is sized to provide predetermined flow rate and purity level of the nitrogen-enriched air based on the increased air pressure.

3. The system of claim 1, further comprising a filter disposed between the air separation module and pressurized air source.

4. The inerting system of claim 3, further comprising a first heat exchanger mounted in said modular unit in communication with said filter and configured to be connected to the compressor, thereby providing a temperature conditioned increased air pressure to the filter.

5. The inerting system of claim 4, further comprising a second heat exchanger mounted in said modular unit in communication with said compressor and configured to be connected to the source of pressurized air, thereby providing a temperature conditioned pressurized air to the compressor.

6. The inerting system of claim 4, further comprising:

a source of cooling air for said heat exchanger;

a temperature sensor configured to monitor a temperature of the temperature conditioned increased air pressure; and

a temperature modulation valve configured to control a flow of the cooling air based on said temperature.

7. The inerting system of claim 4, further comprising:

a source of cooling air for said heat exchanger;

a temperature sensor configured to monitor a temperature of the temperature conditioned increased air pressure; and

a jet pump configured to control a flow of the cooling air based on said temperature.

8. The inerting system of claim 5, wherein the first heat exchanger communicates with a source of cooling air for cooling the compressed air and the second heat exchanger communicates with the source of cooling air for cooling the pressurized air.

9. The inerting system of claim 8, wherein the first and second heat exchangers and air separation module are sized to meet the predetermined flow rate and purity level without a temperature sensor in the air flow through the system.

10. The inerting system of claim 8, wherein the cooling air is provided by a ram air source.

11. The inerting system of claim 8, wherein the cooling air is provided by an NACA scoop.

12. The system of claim 1, wherein the source of pressurized air comprises aircraft engine bleed air.

13. The system of claim 12, wherein the system is mounted in an aircraft having a requirement for nitrogen-enriched air inerting gas, said system comprising a number of said modular units producing a combined flow rate sufficient to meet said requirement.

14. The inerting system of claim 13, wherein said air separation module in each modular unit is sized, in combination with all other modular units, to meet the predetermined flow rate and purity level based on the increased air pressure.

15. The system of claim 13, further comprising a first heat exchanger mounted in said modular unit in communication with said filter and configured to be connected to the compressor, thereby providing a temperature conditioned increased air pressure to the filter.

16. The system of claim 15, further comprising a second heat exchanger configured to receive the engine bleed air, said heat exchanger communicating with the compressor to provide a flow of temperature conditioned air thereto.

17. The system of claim 16, wherein said first heat exchanger, said second heat exchanger, and said air separation module in each modular unit are sized, in combination with all other modular units, to meet the predetermined flow rate and purity level based on the increased air pressure.

18. A modular system for inerting spaces in aircraft, comprising at least one modular unit, wherein:

said at least one modular unit is configured and dimensioned to be mounted in the aircraft and to communicate with said space in a quantity sufficient in combination to meet a nitrogen-enriched flow requirement for inerting said space; and

each said modular unit comprises:

an air separation module configured to be connected to an on-board source of air, said air separation module generating a flow of nitrogen-enriched air corresponding to a portion of said flow requirement;

a turbine disposed in said flow of nitrogen-enriched air; and

a compressor disposed to receive said engine bleed air and deliver it to the air separation module at an increased pressure, said compressor being driven by said turbine.

19. The modular system of claim 18, wherein said modular unit further comprises:

a filter configured to receive the compressed air; and

an air separation module communicating with the filter to produce said nitrogen-enriched air flow.

20. The modular system of claim 18, wherein said turbine and compressor form a part of the modular unit.

21. The modular system of claim 18, wherein said modular unit further comprises a first heat exchanger in communication with said filter and configured to be connected to the compressor, thereby providing a temperature conditioned compressed air to the filter.

22. The modular system of claim 21, wherein said heat exchanger is configured to communicate with a source of cooling air and wherein said modular unit further comprises:

a temperature sensor configured to monitor a temperature of the temperature conditioned compressed air; and

a temperature modulation valve configured to control a flow of the cooling air based on said temperature.

23. The inerting system of claim 21, wherein said heat exchanger is configured to communicate with a source of cooling air and wherein said modular unit further comprises:

a temperature sensor configured to monitor a temperature of the temperature conditioned compressed air; and

a jet pump configured to control a flow of the cooling air based on said temperature.

24. The modular system of claim 21, wherein said modular unit further comprises a second heat exchanger configured to receive the air, said heat exchanger communicating with the compressor to provide a flow of temperature conditioned engine bleed air thereto.

25. The inerting system of claim 24, wherein said first heat exchanger, said second heat exchanger, and said air separation module in each modular unit are sized, in combination with all other modular units, to meet the nitrogen-enriched flow requirement for inerting said space, based on the compressed air.

26. A method for inerting void spaces in aircraft, the aircraft having an inert gas requirement for said inerting, the method comprising:

connecting at least one modular unit to a source of air at a first pressure, said unit producing a flow of nitrogen-enriched air at a predetermined flow rate and oxygen purity level based on air input at a second, higher pressure;

compressing air from the source to said second higher pressure; and

directing the nitrogen-enriched air to the space to be inerted.

27. The method of claim 26, further comprising:

mounting in said aircraft a number of said modular units sufficient to meet the aircraft inert gas requirement with a combination of said predetermined flow rates; and

connecting an output of each of said modular units to the space to be inerted.

28. The method of claim 27, wherein the source of air is engine bleed air.

29. The method of claim 28, wherein each said modular unit comprises:

a filter configured to receive the engine bleed air;

an air separation module communicating with the filter to receive the engine bleed air and produce said nitrogen-enriched air flow;

a turbine; and

a compressor, wherein said compressor compresses the engine bleed air before the air separation module receives the engine bleed air.

30. The method of claim 29, wherein each said modular unit further comprises a first heat exchanger in said modular unit in communication with said filter and configured to be connected to the compressor, thereby providing a temperature conditioned compressed engine bleed air to the filter.

31. The method of claim 30, further comprising:

connecting said modular units to a source of cooling air for said heat exchanger;

monitoring a temperature of the temperature conditioned compressed engine bleed air; and

controlling a flow of the cooling air based on said temperature.

32. The method of claim 30, further comprising:

connecting said modular units to a source of cooling air for said heat exchanger;

monitoring a temperature of the temperature conditioned compressed engine bleed air; and

controlling a flow of the cooling air, using a jet pump, based on said temperature.

33. The method of claim 27, further comprising sizing the modular units to meet said aircraft inert gas requirement without sensing temperature of air flow through said units.

34. The method of claim 26, wherein said compressing comprises:

powering a turbine with said flow of nitrogen-enriched air; and

driving a compressor with said turbine to compress said air.

35. The method of claim 34, wherein said compressing further comprises driving the compressor with power from a motor co-axial to the turbine.

36. The method of claim 26, wherein said compressing comprises powering a turbine with bleed air from a high-pressure sector of an air cycle machine.

37. The method of claim 26, wherein the source of air is a high-pressure sector of an air cycle machine.